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1.—WEST AUSTRALIAN SIMULIIDAE.

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The Simuliidae, which have a world-wide distribution, have been intensively studied in Europe and America on account of their attacks on man and his domestic animals. The Australian representatives with a few exceptions are not characterised by blood sucking habits and hence they have not attracted much attention in the past. In 1925 A. L. Tonnoir (1925) published an account of the Australasian Simuliidae, in which he dealt with twenty-one species of which fifteen were new. In this paper he also reviewed the previous records of species from Australia.

The Simuliidae is a well defined family of Nematocerous Diptera, distinguished from the rest of the super-family Bibionoidea* by the stout body and the broad wings devoid of cross-veins, and without a closed cell. The bases of the main veins are close together and almost parallel. The condition of the vein *Cu* is interesting. Dr. Tillyard (1925) states that the concave bend in the distal part of this vein is a very primitive character, found only in the wing of *Rhyphus*. The occurrence of a similar condition in the wings of Simuliidae must have escaped his attention, as his figures clearly illustrate this point.

The larvae which are sedentary are found together with the pupae, attached to stones and other stationary objects in fresh water streams.

No work has been done previously on the group in Western Australia although the adults were known to be troublesome at certain seasons of the year. It is now known that there are five species represented in the Darling Range area. Two of these I have been unable to identify owing to insufficient material. No female specimens of either of these species were obtained, and as a number of Australian species have been described only from the female, it was thought not to be advisable to describe the male and early stages which however are new.

The other three species, *Simulium ornatipes* Skuse, *S. tonnoiri,* n.sp., and *Austrosimulium bancrofti* Taylor, are very abundant and usually in association with one another although *A. bancrofti* was absent from some localities, *e.g.,* Lesmurdie.

* Mr. A. L. Tonnoir is now of opinion that the family Simuliidae should be placed in the superfamily Culicoidea.

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The adult flies with the exception of the female of *A. bancrofti,* were very rare in the field, although pupae were abundant in the streams. From observations extending from March to November I conclude that the flies breed all the year round where there is running water, even though the stream be reduced to little more than a trickle.

This statement does not apply to one of the undetermined species, which apparently has a very brief breeding period in the winter months. Larvae were quite abundant at Upper Swan in July, but had totally disappeared by September. Curiously enough, only males were obtained from larvae of this species bred in the aquarium.

Pupae and larvae are naturally more plentiful in the spring and early summer, as at this period there is a good supply of water and at the same time the warm weather speeds up the life cycle. With the exception noted above, the adults were never plentiful. In no part of the world are the males very abundant under natural conditions, but usually the females are plentiful in the vicinity of the streams in which they breed.

Simulium tonnoiri, n.sp., seems to have the widest distribution as the early stages are found in all classes of streams. *A. bancrofti,* on the other hand, seems to be more or less restricted to fairly large fast-flowing streams, and it is therefore strange that it does not breed in the Lesmurdie Falls region, as this is certainly one of the major streams in the area under discussion. The early stages of *Simulium ornatipes* are more abundant in slow flowing brooks and are comparatively rare at waterfalls.

Two larvae of an undetermined species of *Austrosimulium* were collected from a small stream in the Cannington Swamps area. This was rather an unusual situation as the water was very discoloured and the stream must have been a very temporary affair. Possibly they had been carried down after heavy rain from some locality in the hills.

BREEDING.

Where possible, the flies were bred in the laboratory from the larvae, as this is the only satisfactory way of definitely connecting the three stages in the life cycle.

In the past, workers on the group were unable to breed the flies from larvae because the latter will not survive under ordinary aquarium conditions, as the aeration is insufficient, and further, as the larvae are sedentary and have no means of creating a current to draw in food, it is obvious that they would speedily starve in standing water. In recent years Tonnoir (1923) and Puri (1925) have successfully reared the adults from eggs under aquarium conditions.

Adults will emerge quite well from pupae if they are kept in a humid atmosphere, *e.g.* on damp cotton wool. Under these conditions larvae will live for a period varying from one to two days, and this is the most satisfactory method of dealing with them at the time of collecting.

The larvae were bred in a cascade aquarium of the style described by Tonnoir (1923) with a few modifications to suit the local conditions. Tonnoir states that in New Zealand the ordinary tap water contains sufficient food for the larvae. This does not apply here, as the water supply is subjected to various purification processes designed to eliminate living organisms. To provide food for the larvae, the water, before entering the cascade was passed through an aquarium where it picked up a certain amount of food material.

Another difficulty was provided by the variation in water pressure. This was overcome to some extent by means of a supply tank fitted with an outlet and an emergency escape tube. The water passed from the tank to the aquarium and was siphoned from the latter to the top of the cascade. The whole apparatus was capable of self adjustment in the event of a fall in water pressure. Such a decrease would lower the water level in each of the containers, and the flow in the cascade would consequently adjust itself. A rise in pressure would not affect the rate of working, as the excess water would escape by the emergency pipe.

In the case of the first batch of larvae the great quantity of rust in the water proved absolutely fatal, all the larvae dying within twenty-four hours. The rust was therefore filtered out as far as possible, but it was found to be impossible to remove it completely without seriously interfering with the running of the aquarium. Chemical methods of removal by precipitation were not attempted as it would be almost impossible to prevent contaminating the water. The rust which was not removed tended to choke the gauze attached to each bowl, and it certainly interfered with the health of the larvae. In many cases when dissections were made it was found that particles of rust constituted the major portion of the contents of the gut.

The construction of the cascade portion of the apparatus was exactly as described by Tonnoir. The object is to obtain a constant stream of water continually and entirely renewing the water contained in a series of small bowls placed one below the other on an inclined plane. This system is very convenient for observation, and when the larvae pupate the cocoons can be removed without difficulty.

In the other type of aerated aquarium which is recommended by Puri (1925), aeration is secured by bubbling air through it. An aquarium of this type was set up, the air current being obtained by means of a filter pump.

This experiment was not a success, possibly in part due to overstocking with larvae, and also to the fact that the aquarium was stocked with *Chara*. This weed is said to prevent the growth of mosquito larvae, and it may have a similar effect upon those of Simuliids. The difficulty of an aquarium of this type is to break up the bubbles of air. If this could be done, aeration would be more complete and the feeding would be more satisfactory.

No further work was done with this type of aquarium, as the cascade type is more convenient. Also, the current of air generated by the filter pump is determined by the water pressure, which, as stated above, is subject to a good deal of variation. A fall in pressure might result in the cessation of aeration, and consequent suffocation of the larvae.

It was found to be more satisfactory to keep the pupae on damp cotton wool in boiling tubes, rather than to allow the adults to emerge in the aquarium. On emergence the flies were allowed to remain in a clean dry tube for some hours before they were killed.

HABITS.

It is fortunate that Australian Simuliidae, with a few exceptions, are not blood-sucking forms, as in many ways the conditions are ideal for their breeding operations. Lea (1917) has reported some severe attacks on cattle in South Australia, but apart from these cases, they are not known to be responsible for much damage, but of course the habits of the majority of the species in Australia are very imperfectly known.

In New Zealand and Tasmania, however, blood-sucking forms are widely distributed, but even in these countries the damage is not extensive, whereas in some parts of Europe and America there are frequent reports of Simuliidae causing the deaths of cattle, horses and pigs. The saliva which the flies inject into the wound appears to have very toxic properties.

Only three Australian species have been definitely recorded biting man. The first record was that of *Austrosimulium bancrofti* from Queensland, and since then *Simulium terebrans* and *S. fergusoni* have been added from New South Wales and Victoria. *A. bancrofti* occurs quite abundantly in the Darling Range area of this State, and it is the only biting species so far recorded here. They are particularly vicious during the spring and early summer, and bite from morning to night, not only along the banks of the streams, but they also enter dwellings some distance from their breeding places.

Female flies of this species, taken in the field, bite freely in captivity when applied to the skin, but those bred out in the laboratory never exhibited this habit. After the bite, the irritation does not commence for a considerable time, twelve hours or more usually. Some persons are much more susceptible than others, the bites in their cases producing large swellings which later become almost black. These are intensely irritating and persist for nearly a fortnight, during which time a pus-filled head forms in the centre of each.

In accordance with their blood-sucking habits, Simuliidae at various times have been reported as carriers of disease. The first charge of this sort was made by Dr. Louis Sambon, who suspected that they were the vectors of pellagra, a fatal human disease in many parts of the world. This has since been shown to be due to an improper diet.

In South Africa, *Simulium damnosum* Theo., has been proved to be the carrier of *Onchocerca volvulus,* a nematode worm. The South American workers suspect Simuliidae of performing the same service for a closely allied parasite, *O. caecutiens.*

The work of Dry (1921) in Kenya indicates that *Simulium neavei* Roubaud, is the transmitter of a disease of natives characterised by a peculiar wrinkling of the skin and various internal disorders.

PREDATORS.

As might be expected from their sedentary habit, the early stages of Simuliidae are preyed upon by other aquatic animals. In the case of *S. tonnoiri,* n.sp., the cocoons are built in clumps and often Chironomid larvae were present about the bases of these, and in the material which collected there. In one case a Chironomid bred out from a tube containing these cocoons, and hence its pupa must have been present. If both the larvae and pupae are present in this situation it seems probable that the Chironomid larvae feed on the Simuliids.* In Eastern Australia and America, dragon-fly larvae have been observed feeding on Simuliid larvae, and on one occasion I observed a similar habit under aquarium conditions. The dragon-fly larva, which was placed in a bowl of the cascade aquarium, devoured eight larvae in the course of ten minutes. The fact that this larva had been starved for over a week no doubt made the Simuliids more acceptable than they would be under natural conditions. The possibility of using dragon-fly larvae to control the Simuliid pest in New Zealand is being investigated by Mr. A. L. Tonnoir.

* Mr. A. L. Tonnoir has pointed out that it is quite possible that the Chironomid larvae are merely commensals.

SYSTEMATICS.

Until recently the Simuliidae throughout the world were grouped into a single genus Simulium. In 1921, Dr. G. Enderlein (1921) brought forward a classification subdividing the genus into a number of genera. His classification was unsatisfactory, and has not met with wide acceptance.

A. L. Tonnoir (1925), working on Australasian forms, divided them into two genera. Those with antennae composed of eleven segments he left in the genus *Simulium*, and those with antennae composed of ten segments he placed in a new genus, *Austrosimulium*. This classification is satisfactory except in the case of *A. bancrofti*, the position of which will be discussed later. Tonnoir found that many of the species of *Austrosimulium* were almost indistinguishable in the adult stage, but that the early stages showed good systematic characters.

The most satisfactory characters of the adults for systematic purposes are the relative lengths of the joints of the antennae, and of the maxillary palps, the degree of curvature of the vein *Cu*, the tarsal joints of the hind leg and, in some cases, the genitalia. The Western Australian forms are easily separable on these characters, and also on their colouration which, however, is somewhat variable.

The larvae offer excellent systematic characters in the structure of the antennae, the arrangement of the teeth of the submentum, and in mature forms the shape of the gill spot. The anal armature is also distinctive but rather variable, and the same remark applies to the markings of the head capsule.

All the previously described Australasian larvae had antennae consisting of only two segments and an apical cone. It is curious that the antennae of all the Western Australian forms should have three segments* in addition to the cone. The division between the two basal segments is not so distinct as that between the second and third joints, but there are undoubtedly three segments present.

The pupal breathing organs are quite distinctive. Previously *S. aurantiacum* Tonn., was the only Australian species with branched pupal gills, but *S. tonnoiri*, n.sp., also shows this condition. The species of the genus Simulium so far described from Australasia are characterised in the pupal stage by the absence of a prominent basal horn, to which, in the case of *Austrosimulium*, the filaments of the gills are attached. The cocoon shows wide differences in shape and texture in the various species. The wall may be almost membranous and transparent, or it may be quite rough and, in some cases, foreign matter is incorporated in it. The cocoon may be attached by its ventral surface or by the posterior end only. Of the three species dealt with, two belong to the genus *Simulium*, and the third to *Austrosimulium*. As Taylor (1927) has pointed out, the position of *A. bancrofti* is doubtful. The genus *Austrosimulium* was erected by Tonnoir, the generic character being the condition of the antennae which were composed of ten segments. In Taylor's original description *A. bancrofti* was described as having nine segmented antennae, and all the specimens which I have examined exhibit this character. Tonnoir (1925) has amended this description and stated that the antennae are composed of ten segments, and hence he put the species in the genus *Austrosimulium*.

* In a letter Mr. A. L. Tonnoir has expressed doubt as to whether the antennae of the larvae are truly three-segmental. He suggests that the suture dividing the first and second segments may either be a trace of former segmentation or a fold due to telescoping of the segment before moulting. Personally, I am satisfied that there are three true segments present.

Taylor (1927) does not agree with this correction, and as all my specimens agree with his in this respect it seems probable that Tonnoir's specimens are exceptional.

Apart from the antennae there is no known adult character on which to separate the two genera, and therefore it is doubtful whether *A. bancrofti* should be retained in that genus. The male and early stages of this species are described for the first time in this paper.

Although *Simulium ornatipes,* Skuse, was one of the earliest known forms from Australia, the early stages have remained undescribed until now.

I also record a new species which I have named *Simulium tonnoiri,* n.sp., in compliment to Mr. A. L. Tonnoir, to whom I am greatly indebted for advice and aid in the matters of literature and named specimens.

Simulium ornatipes Skuse.

Skuse. Proc. Linn. Soc. N.S.W. 1890.

Tonnoir. Bull. Ent. Research. Vol. XV., Pt. 3, 1925.

Larva.—Length, 5-6 m.m.

Head.—Prefrons light with medium dark stripe from close to hind edge to just past the middle; two black spots near hinder end of stripe; and two smaller spots very close to it about 2/3rds of distance along it; rest of head capsule light except around the eyes and along the hinder edge laterally.

Antennae (Fig. 1, A) composed of three joints; second joint 1¼ times length of first; third joint shorter than 1st; two basal joints together as long as basal piece of the fan.

Submentum (Fig. 1, C) with three prominent teeth and between the central one and each lateral one are three small teeth.

Gill spots (Fig. 1, B) very large with an abrupt anterior ventral angle.

Body of greenish grey colour, darker posteriorly; two prominent ventral papillae at hinder end; anal gills simple; descending rods of anal armature bent out at lower end. Posterior sucker consists of numerous rows of 12-15 hooks.

Pupa.—Pupal gills (Fig. 1, D) consist of four stout filaments coming off as two pairs one above the other; basal horn very short; ventral filaments longer than dorsal ones.

Cocoon (Fig. 1, E).—Fairly open texture; applied to surface by ventral side; ventral wall of cocoon complete anteriorly and posteriorly, but absent in centre; prominent ventral rim at anterior end.

The cocoons and larvae are found attached to stones and other stationary objects, but more abundantly to grasses dipping in the water. The pupal period lasts 6-8 days.

This species does not seem to require a very fast current, and is more plentiful in the smaller streams.

Simulium tonnoiri, n.sp.

Male.

Length of body, 2.3 m.m.

Head.—Face brown, pubescence gold. Antennae composed of eleven joints; second segment brown, the rest yellow; 2nd and 3rd segments subequal about 1¼ times length of the 1st; 4th-10th joints sub-equal slightly more than ½ length of 2nd; 11th joint as long as the 2nd. Mouth parts brown; 1st two palpal joints small and cyathiform; 3rd joint longer than 4th; 5th joint 2¼ times length of 4th.

Thorax.—Mesonotum brown or somewhat orange; darkened on medium rather broad band; pubescence short, golden, thicker anteriorly; scutellun with long yellow hair; pleurae light brown, two tufts of yellow hair present; mesosternum brown. Anterior and middle legs approximately equal; hind legs larger. Forelegs lighter in colour than others; mainly yellow and the pubescence yellow; tibia darkened at the base. Middle legs with femur and tibia both darkened near base; coxae dark, pubescence black and yellow. Hind legs similar colour but darkening more pronounced; metatarus produced into a distal internal lap of full width but narrowed at the base so as to produce a notch. Lap extends about two-thirds of length of 2nd joint. Claws with a basal tooth.

Wings.—Membrane clear except between *C* and *Sc* where it is yellow. *Cu* slightly undulating. A very distinct black stigma is formed by a thickening of *R* in region of its fork, of the cross vein *r-m*, and *M* just before it forks. Halteres yellowish.

Abdomen.—Black, pubescence yellow; basal side tufts long, yellow.

Genitalia (Fig. 2, A).—Basal segment of clasper stout, 2nd joint short and curved bearing two teeth at apex.

Female.

Length of body, 2.9 m.m.

Head.—Frons about 1/11th of width of the head; frons and face brown with yellow pubescence. Antennae with coloration as in male; first and second segments subequal; 3rd shorter; 11th slightly longer than 1st. Mouth parts brown; 1st joint longer and narrower than 2nd; 3rd joint slightly longer than fourth and 1½ times as wide; 5th joint twice length of 4th. The joints are stouter than the corresponding joints in the male.

Thorax.—As in the male; somewhat variable, some specimens being much darker than others. Legs as in male, but stouter. Claws with a prominent tooth at base.

Abdomen.—Similar to that of male.

Genitalia (Fig. 2, B).—Basal segment large; subgenital fork stout.

Types bred from pupae collected at Lesmurdie, 18/10/30.

Larva.—Length, 7-8 m.m.

Head.—Median dark line extends for more than halfway along prefrons; dark spot on either side of this line about middle of its length; dark coloration extends up beyond level of base of antennae; eyes in a clear space; capsule darkened posteriorly. Antennae (Fig. 3, A) composed of three joints; 1st joint slightly shorter than 2nd. 3rd is 1½ times length of 1st. Antennae slightly shorter than basal piece of fan.

Submentum (Fig. 3, C) with three prominent teeth; median one separated from each of lateral ones by three small teeth of which central one is smallest; outside each lateral tooth is a further large one at a lower level and separated from the former by three small teeth. Body, grey in colour but varies considerably.

Gill spots (Fig. 3, B) with a large ventral lobe. Posterior sucker is composed of numerous rows of from 18-24 hooks.

Pupa.—The pupal gills (Fig. 3, D) consist of 27-35 rigid filaments proceeding from three main trunks. The number of filaments is very variable, some having as many as 40, and others as few as 20. The terminal abdominal hooks are very large in this species.

Cocoon (Fig. 3, E).—Very rough, all sorts of foreign material being incorporated in its formation. The cocoon, which fits the pupa tightly, is applied to the support by its ventral surface if isolated but usually the cocoons are built in clumps of 10 or more, and in such cases they are attached to the support by their posterior ends only. The cocoons are found attached to stones but rarely to grasses. This species is equally common in slow and fast streams. It is obviously closely allied to *Simulium aurantiacum* Tonn. and resemblances between the two species are common in both adult and early stages. The adults can be recognised by the stigma in the wing. In life the upper portions of the eyes of the males are brilliant orange and the eyes of the female show a corresponding distribution of colour, but it is less pronounced.

These are the only two Australian species with branched pupal gills, but in *S. tonnoiri*, n.sp., the branching is more extensive.

Austrosimulium bancrofti, Taylor.*

F. H. Taylor, Australian Zoologist, Vol. 1, Pt. 6, 1918.

A. L. Tonnoir, Bull. Ent. Res., Vol. XV., Pt. 3, 1925.

F. H. Taylor, Bull. Ent. Res., Vol. XVIII., Pt. 1, 1927.

The female of this species has been described by Taylor from Queensland. As stated above, the condition of the antennae has provided some discussion, but all my specimens agree with the descriptions given by Taylor. The male and early stages are herewith described for the first time:—

Male.—Length, 1.8 m.m.

Head.—Black, mouth parts dark; pubescence grey. Antennae composed of nine segments; first three joints cyathiform; 2nd joint 1½ times length of 1st; 3rd joint 1½ times length of 2nd; 4th slightly smaller than 2nd; 5th-8th small, subequal; 9th nearly as long as 3rd, tapering.

Maxillary palps dark; 1st two joints small, 3rd enlarged proximally somewhat larger than 4th, which is swollen distally; 5th narrow, nearly twice length of 4th.

Thorax.—Velvety black, pubescence grey; hairs on scutellum long and black; pleurae grey. Anterior and middle legs approximately equal; coloration similar; coxae dark; femur and tibia darkened at base and tibia also darkened distally; tarsal joints dark, pubescence black. Hind legs larger, coxae light, otherwise coloration similar. Metatarsus has a slightly undulating anterior edge, produced distally into a short internal lap of only half width; lap projects only to one-fifth of length of 2nd tarsal joint and does not reach notch in latter. Claws with a tooth at the base. Wings.—*Cu* deeply curved. Halteres yellow.

* There is some doubt as to the correct identification of this species. The adult female appears to be indistinguishable from the type, but until the early stages have been described from the district in which the typs were collected, certainty cannot be reached.

I should also state that many of the new stages described in this paper have been known in the Eastern States by Mr. Tonnoir for some time, and that he has kindly allowed me to describe them. In all cases, however, the descriptions were made from West Australian material.

Abdomen.—Black, pubescence black and grey without ash grey spots as in the female; side tufts at base, grey.

Genitalia (Fig. 2, C).—Claspers long, 2nd segment slender, bearing four teeth.

Type bred from pupa collected at Serpentine, 16/4/30.

Larva.—Length, 5-6 m.m.

Head.—Rather light but depth of colour is variable; darkened on posterior margin, on a medium dorsal line and on thin line behind each eye. Antennae (Fig. 4, A) composed of three segments; 2nd joint 1⅓ times the 1st; 3rd slightly longer than 2nd. Antenna is slightly shorter than basal piece of fan.

Submentum (Fig. 4, C) with reduced teeth, only four project; two teeth between median tooth and each of outer large teeth.

Body.—Greenish grey in colour. Gill spot (Fig. 4, B) narrow, obliquely placed. Anal gills simple; from each of the dorsal expansions of the anal armature, a narrow rod runs to bases of the descending rods. Posterior sucker composed of rows of 20-25 teeth.

Pupa.—Gills (Fig. 4, D) consist of numerous narrow unbranched filaments given off from the base of a prominent projection with a papillose surface; projection extends beyond ends of filaments which are ringed at the base.

Cocoon (Fig. 4, E).—Transparent and membranous texture; it is set obliquely on its support by the posterior end, which is open; free end smaller and the edge is thickened.

The cocoons are found attached to stones and sticks but rarely to grasses This species is more abundant in fast flowing streams. The pupal period lasts from four to six days.

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EXPLANATION OF FIGURES.

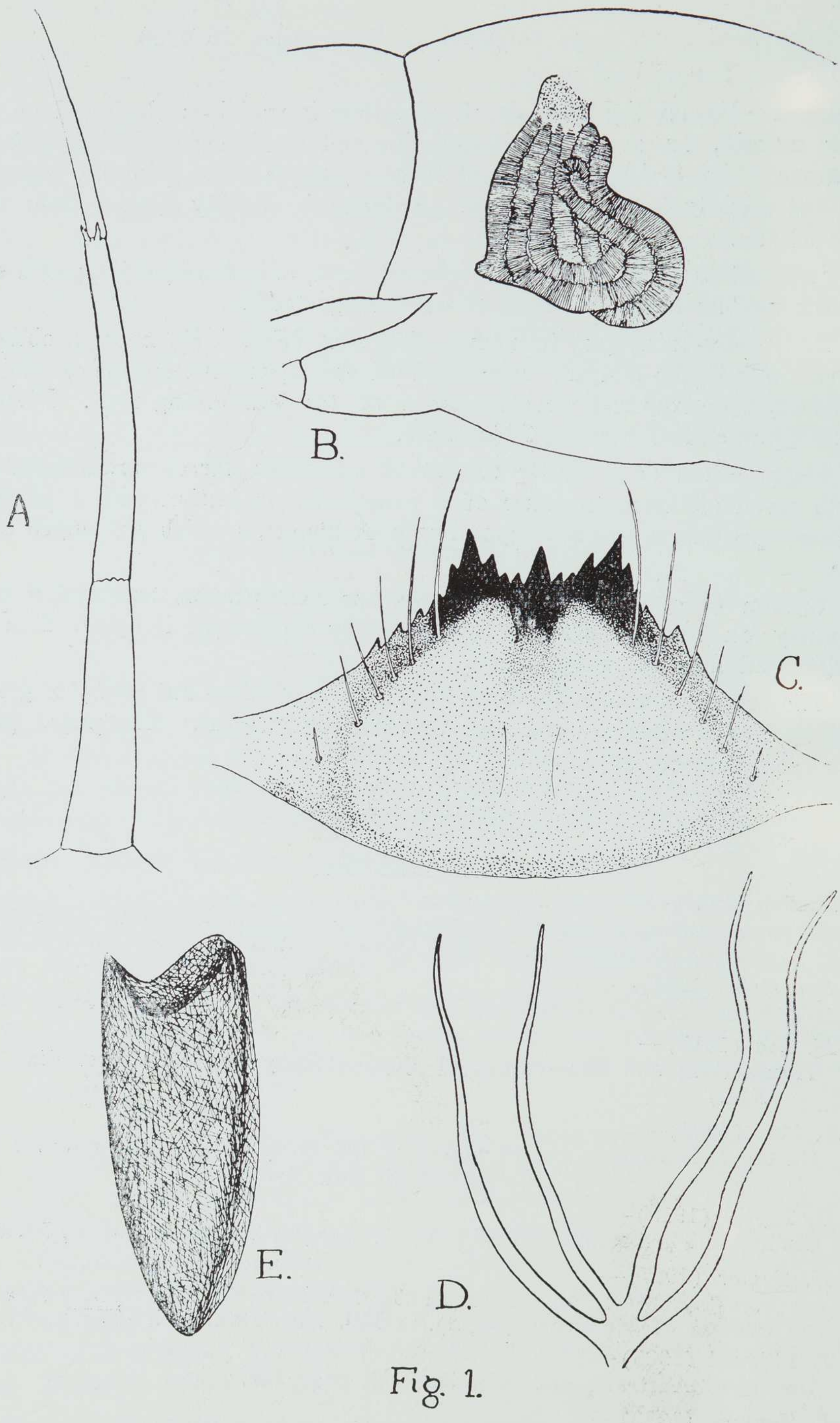

Fig. 1.—*Simulium ornatipes* Skuse. Larva.

A. antenna, B. gill spot, C. submentum, E. cocoon, D. pupal gills.

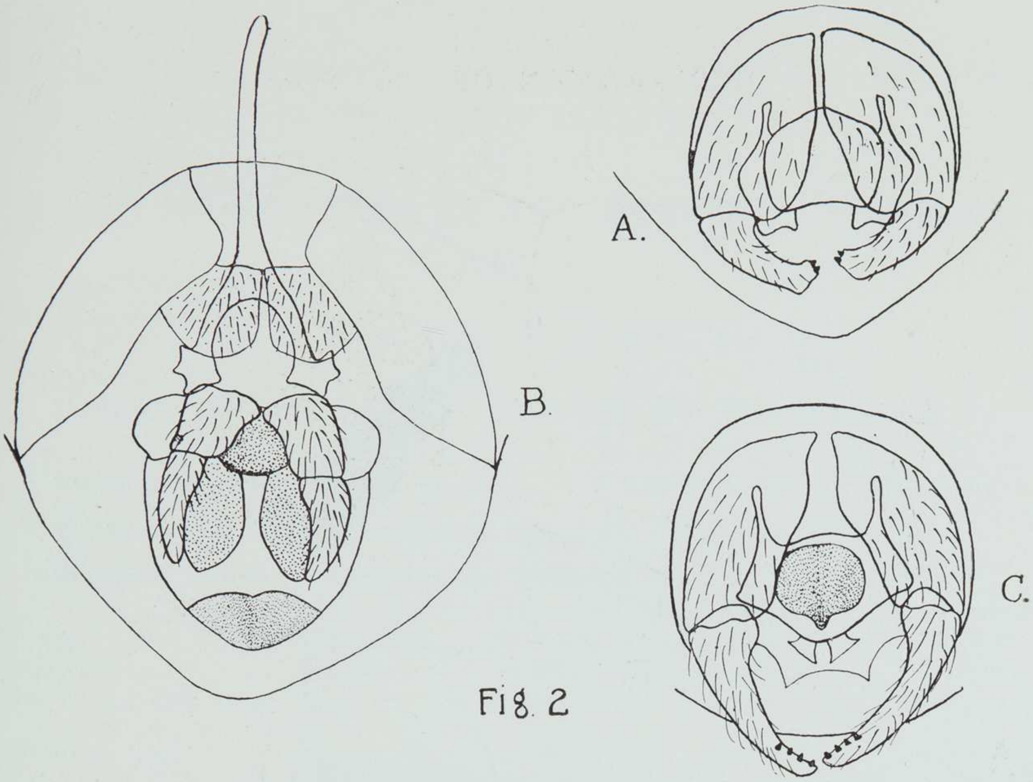

Fig. 2.—A. male genitalia of **Simulium tonnoiri** n.sp.
B. female genitalia of *Simulium tonnoiri* n.sp.
C. male genitalia of *Austrosimulium bancrofti* Taylor.

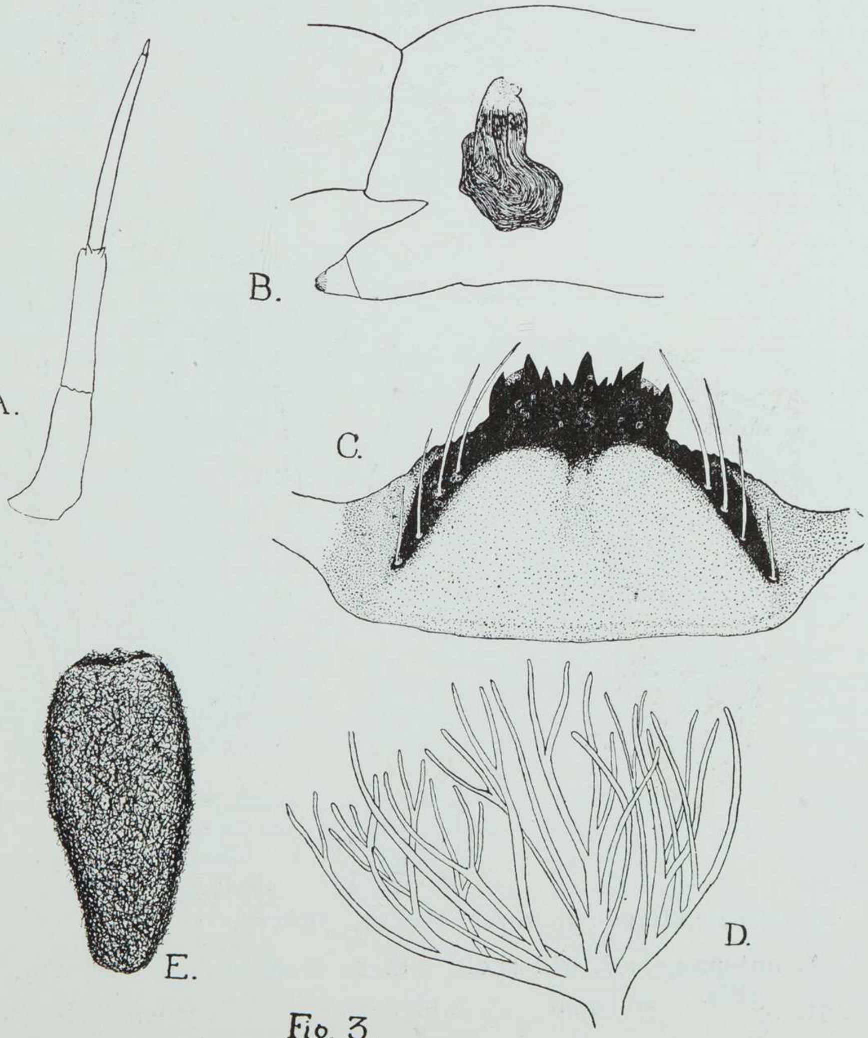

Fig. 3.—A. antenna, B. gill spot, C. submentum, E. cocoon, **D. pupal** gills.

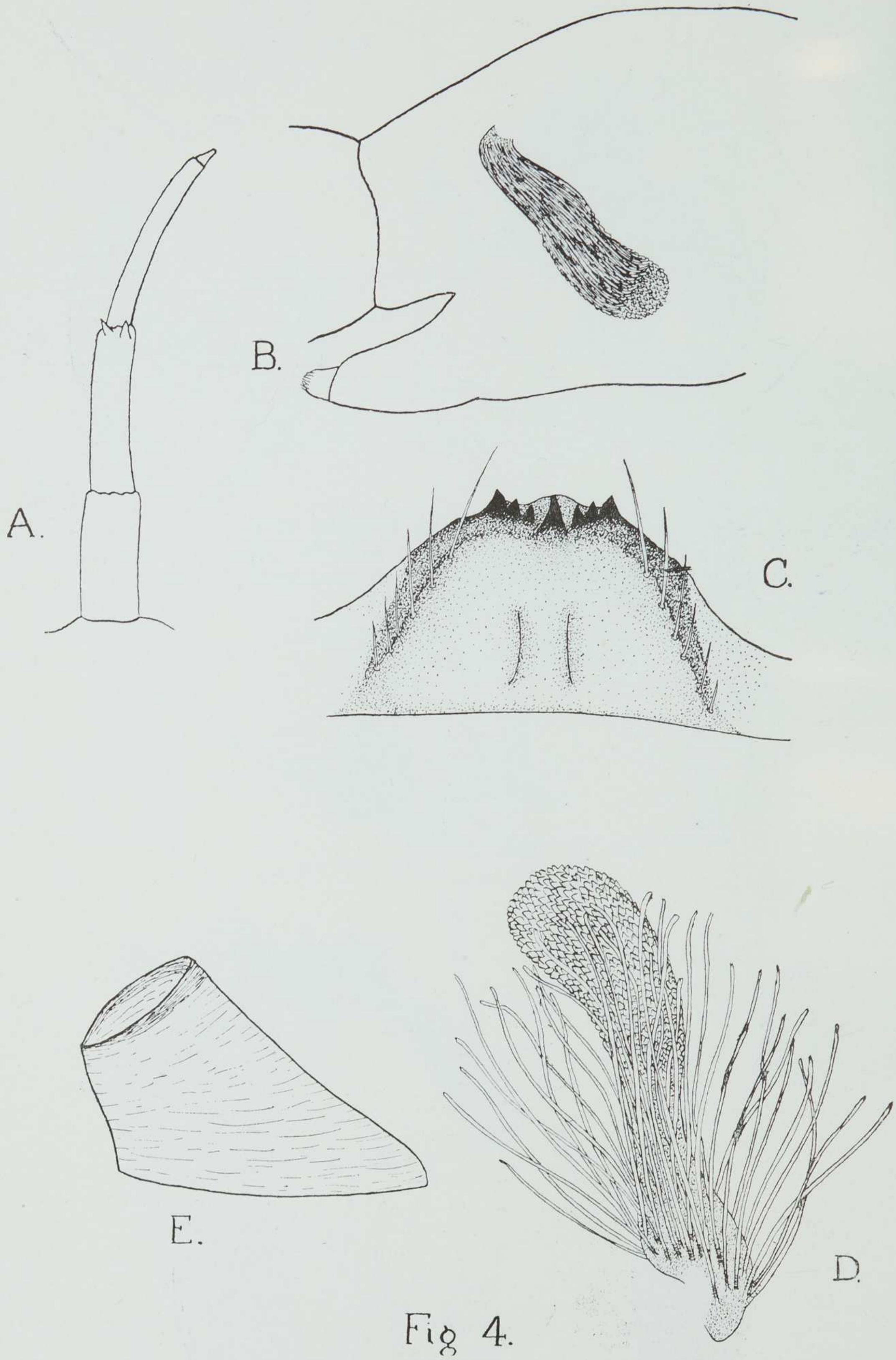

Fig. 4.—*Austrosimulium bancrofti* Taylor. Larva.

A. antenna, B. gill spot, C. submentum, E. cocoon, D. pupal gills.

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